

CHAPTER 5

MECHANICAL AND ELECTRICAL MAINTENANCE

OVERVIEW

Describe the safety requirements relating to mechanical and electrical maintenance.

Describe mechanical maintenance guidelines.

Describe maintenance requirements for surface vessel and submarine torpedo tubes.

Describe electrical maintenance guidelines.

OUTLINE

Safety

General maintenance

Mechanical maintenance

Surface vessel torpedo tube maintenance

Submarine torpedo tube maintenance

Electrical maintenance

Maintenance means everything you do to “keep ’em firing.” It means knowing your equipment and keeping it in shape to do its job. In this chapter we shall take up maintenance in terms of the specific work that you will be expected to do with torpedo tubes and test equipment. Your job is to have every torpedo tube ready to operate at all times and to keep every weapon in the fight.

In time of war, preventive maintenance saves more than time and repairs. You probably remember the poem that tells how, for want of a missing horseshoe nail, a battle was lost. The horse’s shoes should have been inspected, and the missing nail replaced—just a matter of preventive maintenance. Of course, we do not use horseshoe nails aboard modern warships, but see the analogy. Maintenance can mean the difference between victory and defeat, both ashore and afloat. If anything goes wrong with the fighting equipment of a ship, it is out of action until repairs can be made, and then it might be too late. You have been around long enough to know that a ship’s fighting equipment is very complicated with many parts dependent on other parts. A great deal of money and ingenuity have gone into that equipment. But if it is not in working order when needed, it is worthless.

We will begin our discussion by covering the safety aspects of mechanical and electrical

maintenance. Then we will talk about hydraulic/mechanical maintenance and electrical maintenance. After we have covered the basics of these areas, we will apply what we have discussed to the surface and submarine torpedo tubes and the test equipment that you will be responsible for maintaining on a day-to-day basis.

SAFETY

The primary reason for the vast amount of information available on the subject of safety precautions is simply the desire to prevent accidents. Research shows that a majority of all accidents comes through sheer carelessness. Not only is there a loss of time involved in an accident, but also there is an accompanying loss of equipment, material, or, in an extreme case, life itself. Aside from these important considerations, there is a vast amount of money wasted in replacing damaged equipment, performing investigations, paying for hospitalization or funerals, and for loss of man-hours resulting in convalescence. These are but a few of the problems faced every day by the Navy because personnel fail to heed the posted and required safety precautions.

Safety is everybody’s job. Awareness of danger, knowledge of how to avoid it, and

constant vigilance are the three basic requirements for the prevention of accidents while you are working on or operating ordnance equipment.

Practical safety features are incorporated into Navy equipment to eliminate potential hazards to personnel. Since familiarity with equipment leads to carelessness, observation of all safety notices and rules is mandatory. A relaxation of vigilance shall never be permitted.

Each piece of ordnance equipment has a specific list of safety precautions to be observed during operation and/or maintenance. Study these thoroughly before attempting to operate or repair this equipment.

Before we can start talking about actually performing any maintenance on torpedo tubes or test equipment, we will go over a few of the safety tips that you will see over and over again. But since it may mean the difference between life and death, here it is again.

MECHANICAL SAFETY

The mechanical maintenance you will perform is so wide ranging that there is no way we can cover every area of safety that you will need to know, but we will attempt to discuss some of the main areas that you will encounter. The first and possibly most used areas are the hydraulic and pneumatic systems.

Hydraulic\Pneumatic Safety

These are but a few of the safety rules that must be observed when operating or working on these systems.

- Never disconnect hydraulic lines or disassemble hydraulic equipment when the hydraulic system power motor is running.
- Never disconnect hydraulic lines or disassemble hydraulic equipment until the accumulators have been manually dumped to tank.
- Never manually actuate switches, solenoids, relays, or valves on hydraulic systems under pressure unless you are competent and qualified to perform these actions.
- Report hydraulic leaks immediately so that they may be repaired at the first opportunity.
- If clothing becomes drenched with hydraulic fluid, immediately change into dry clothing, for hydraulic fluid is injurious to your health when in prolonged contact with the skin. Additionally it is a fire hazard; because of this fact, spills should be immediately wiped up.
- Never spray hydraulic fluid, heat it to its flash point, or otherwise subject it to conditions that cause vaporization.
- Do not handle hydraulic fluid in the presence of electrical sparks or open flames.
- Do not mix air and hydraulic fluid in a pressurized system. An explosive mixture could result (commonly known as diesel-action).
- Never use oil on gauges associated with pneumatic systems. Do not use an oil gauge on an air system. Check the accuracy of gauges frequently as prescribed by maintenance requirement schedules.
- Do not close or open air or hydraulic valves rapidly unless authorized to do so.
- Before mating air and hydraulic system coupling, inspect the threads making certain they are free of dirt, oil, and physical defects.
- Do not direct a high-pressure air jet at any part of the human body; this maybe fatal.
- All personnel taking part in and observing operation of power equipment shall remain alert, keep clear of moving parts, and be thoroughly familiar with the safety precautions applicable to that equipment. At no time will skylarking be tolerated.
- Hydraulic systems operate under hydraulic pressures ranging from approximately 100 psi to 3000 psi. Some pneumatic systems operate in approximately the same range of pressures as hydraulics. These pressures are dangerous and can be hazardous.

Safety precautions must be observed when performing maintenance, testing, and operating ordnance hydraulic and pneumatic equipment.

The high pressure liquid or air can cause major injuries to your face, hands, and other parts of the body by jets of air or liquid escaping from highly pressurized valves or pipe connections.

Tool Safety

There are a few basic rules that you should keep in mind when using wrenches:

- Always use a wrench that fits properly.
- Keep wrenches clean and free of oil. Otherwise, they may slip, resulting in possible injury or equipment damage.
- Do not increase the leverage of a wrench by placing a pipe over the handle. Increased leverage may damage the wrench or the work.
- Determine which way a nut should be turned before trying to loosen it; most nuts are turned counterclockwise for removal. This may seem obvious, but even experienced personnel have been observed straining with a wrench in the tightening direction when they wanted to loosen it.

The following precautions should be observed when using torque wrenches:

- Do not use the torque wrench as a hammer.
- When using the micrometer setting type, do not move the setting handle below the lowest torque setting. However, it should be placed at its lowest setting prior to being returned to storage.
- Do not use the torque wrench to apply greater amounts of torque than its rated capacity.
- Do not use the torque wrench to break loose bolts which have been previously tightened.
- Never store a torque wrench in a toolbox or in an area where it may be damaged.

Be thoroughly familiar with all posted safety precautions and those listed in the OP pertaining to the equipment to which you are assigned.

Do not think that once you have learned all applicable safety precautions you can sit back and take things easy. Review the precautions periodically, particularly those for jobs seldom performed. Try to improve upon any rules in effect. Safety is everyone's responsibility, not just those who drew up the regulations. Most accidents are caused by personnel who are so familiar with their job that they think they can take shortcuts; by personnel who do not know the applicable precautions; by practical jokers; or in the majority of instances, by personnel exercising plain carelessness.

ELECTRICAL SAFETY

You will install, maintain, and repair electrical and electronic equipment in confined spaces in which dangerously high voltages are present. Among the hazards of this work is the possibility of injury caused by electric shock, electrical fires, harmful gases, and the improper use of tools.

Because of these dangers, you should develop safe and intelligent work habits. You should always be on the lookout for dangerous conditions and avoid unsafe acts. You must also know the authorized methods for dealing with fires of an electrical origin. You must know how to treat burns and how to give artificial ventilation (respiration) to persons suffering from electric shock. In some cases, you may have to perform external heart compression in addition to artificial ventilation to restore the heartbeat. (Artificial ventilation and external heart compression performed together is known as cardiopulmonary resuscitation [CPR].)

The life of a shipmate may easily depend upon your CPR skills. This statement is not meant to indicate that knowledge of other first-aid procedures are less important; rather, it is meant to alert you of the importance of being currently certified in the special skills of CPR in order to take immediate, correct, and successful actions in the event of heart stoppage and/or breathing stoppage.

Electric Shock

Electric shock may cause burns of varying degree, the stoppage of breathing and unconsciousness, ventricular fibrillation or cardiac arrest, and death.

If a 60-hertz alternating current is passed through a person from hand to hand or from hand to foot, the effects when current is gradually increased from zero are as follows:

- At approximately 1 milliampere (0.001 ampere), the shock will be felt.
- At approximately 10 milliamperes (0.01 ampere), the shock is severe enough to paralyze muscles and a person may be unable to release the conductor.
- At approximately 100 milliamperes (0.1 ampere), the shock is usually fatal if it lasts for one second or more. Remember that current, rather than voltage, is the fundamental cause of shock intensity.

You should clearly understand that the resistance of your body will vary. That is, if the skin is dry and unbroken, body resistance will be quite high—300,000 to 500,000 ohms. However, if the skin becomes moist or broken, body resistance may drop to as low as 300 ohms. Thus, a potential as low as 30 volts could cause a fatal current flow. Therefore, any circuit with a potential in excess of this value must be considered dangerous.

Electric shock is caused by contact with an electric circuit. The victim usually experiences a jarring, shaking sensation or the sensation of a sudden blow. If the voltage is sufficiently high, unconsciousness results. Severe burns may appear on the skin at the place of contact.

Shock causes muscle spasms, which results in a person clasp the tool or wire that caused the shock and rendering him unable to turn it loose. Electric shock can kill its victim by stopping the victim's heart or his breathing. It may damage nerve tissue, which may result in a wasting away of muscle. This damage may not become apparent until several weeks or months after the shock is received.

The following procedure is recommended for rescue and care of shock victims:

1. Remove the victim from the electrical contact at once, being careful not to endanger yourself; you can do this by (a) de-energizing the primary power switch if it is nearby or (b) using a dry stick, rope, leather belt, coat, blanket, or any other nonconductor of electricity to pull the victim away from the electrical contact.

2. Determine whether the victim is breathing. If so, keep the person lying down in a comfortable position. Loosen the clothing about his neck, chest, and abdomen so that the person can breathe freely. Take precautions to protect the victim from exposure to the cold, and maintain a watch of the victim's behavior.

3. Keep the victim from moving about. After shock, the heart is very weak, and any sudden muscular effort or activity may result in heart failure.

4. Do not give the victim stimulants or depressants. Send for a medical officer at once and do not leave him until adequate medical care is given.

5. If the victim is not breathing, you must apply artificial ventilation without delay, even though the victim may appear to be lifeless.

Working on Energized Circuits

Insofar as is practical, you should not undertake repair work on energized circuits and equipment. However, it could become necessary, such as when you make adjustments on operating equipment. In such cases, obtain permission from your supervisor, then proceed with your work, and carefully observe the following safety precautions:

- Have adequate lighting to safely and properly perform the job.
- Insulate yourself from the ground by an approved rubber mat or layers of dry canvas and/or wood.
- Where practical, use only one hand, keeping the other either behind you or in your pocket.
- Wear rubber gloves, if you expect voltage to exceed 150 volts.
- Station an assistant near the main switch or circuit breaker so the equipment can be immediately de-energized in case of an emergency.
- Station someone that is qualified in first aid for electric shock in the proximity during the entire operation.
- DO NOT WORK ALONE.

- DO NOT work on any type of electrical apparatus when you are wearing wet clothing or if your hands are wet.
- DO NOT wear loose or flapping clothing.
- DO NOT wear thin-soled shoes and shoes with metal plates.
- Flammable articles should not be worn, such as celluloid cap visors.
- Remove all rings, wristwatches, bracelets, and similar metal items before working on equipment. Also ensure that your clothing does not contain exposed metal fasteners, such as zippers, snaps, buttons, and pins.
- DO NOT tamper with interlock switches; that is, do not defeat their purpose by shorting them or blocking them open.
- Ensure that equipment is properly grounded before energizing.
- De-energize equipment before attaching alligator clips to any circuit.
- Check for the presence of voltage only with approved meters and other indicating devices.

Working On De-Energized Circuits

When any electronic equipment is to be repaired or overhauled, certain general safety precautions should be observed. They are as follows:

1. Remember that electrical and electronic circuits often have more than one source of power; take the time to study the schematics or wiring diagrams of the entire system to ensure that all sources of power have been disconnected.
2. If pertinent, inform the remote station regarding the circuit on which work will be performed.
3. Use one hand when turning switches on or off.
4. Safety devices, such as interlocks, overload relays, and fuses, should never be altered or disconnected except for replacement. In addition, they should never be changed or modified in any way without specific authorization.

5. Fuses should be removed and replaced only after the circuit has been de-energized. When a fuse blows, the replacement should be of the same type and have the same current and voltage ratings. A fuse puller should be used to remove and replace cartridge fuses.

6. All circuit breakers and switches from which power could possibly be supplied should be secured (locked if possible) in the OPEN or OFF (safe) position and tagged.

7. After the work has been completed, the tag (or tags) should be removed only by the person(s) who signed it when the work began.

8. Keep clothing, hands, and feet dry if at all possible. When you must work in wet or damp locations, place a rubber mat or other non-conductive material on top of a dry, wooden platform or stool to sit and stand on. Use insulated tools and insulated flashlights of the molded type when you are required to work on exposed parts.

Electrical Fires

No one will argue with the statement that fires are a hazard. They are such a hazard that we have classified them: A, B, and C. Class A fires involve wood, paper, cotton and wool fabrics, rubbish, and the like. Class B fires involve oil, grease, gasoline and aircraft fuels, paints, and oil-soaked materials, and class C fires involve insulation and other combustible materials in electrical and electronic equipment.

Electrical or electronic equipment fires result from overheating, short circuits (parts failure), friction (static electricity), or radio-frequency arcs. Also, equipment may be ignited by exposure to nearby class A or B fires. Since class C fires involve electrical circuits, electric shock is an added hazardous condition. Thus, whenever possible, any electrical equipments exposed to a class A or class B fire, or actually ignited by such a fire, should be de-energized immediately. If the equipment cannot be de-energized completely, you must use protective measures to guard against electric shock. In addition, extinguishing agents other than gases will contaminate delicate instruments, contacts, and similar electric devices. Therefore, carbon dioxide (CO₂) is the preferred extinguishing agent for electrical fires because it does not conduct electricity and it rapidly evaporates, leaving little or no residue. Thus, its use reduces the possibility of electric shock to personnel and damage to delicate equipment as a result of contamination.

A dry chemical type of extinguishing agent, composed chiefly of potassium carbonate (Purple-K), is suitable for electrical fires because it is a non-conductor and provides protection against electric shock. However, damage to electrical or electronic parts may result from the use of this agent. The dry chemical extinguisher is similar in appearance to the CO₂ extinguisher.

A solid stream of water must never be used to extinguish electrical fires in energized equipment. Water usually contains minerals that make it conductive; the conductivity of sea water is many times greater than that of fresh water. Pure distilled water is not a good electrical conductor and, therefore, may be used in an emergency on small electrical fires. If circumstances demand the use of fresh water or seawater, fog produced by a special hose nozzle (fog head or tip) maybe used in electrical or electronic equipment spaces. The fog, which is a fine diffusion or mist of water particles, has very little conductivity.

Foam is not recommended for electrical fires because of equipment damage and possible shock hazard to personnel; however, if necessary, foam may be used only on de-energized circuits. When a blanket of foam is applied to a burning substance, the foam smothers the fire; that is, it cuts off the air supply to the burning substance. Thus, the supply of oxygen necessary to support combustion is isolated from the substance, and the fire will be extinguished.

The following general procedure is used for fighting an electrical fire:

1. Promptly de-energize the circuit or equipment affected.
2. Sound an alarm in accordance with station regulations or the ship's fire bill. When ashore, notify the fire department; if afloat, notify the officer of the deck. Give the fire location and state what is burning. If possible, report the extent of the fire; that is, what its effects are upon the surrounding area.
3. Secure ventilation by closing compartment air vents or windows.
4. Control or extinguish the fire using a CO₂ fire extinguisher.
5. Avoid prolonged exposure to high concentrations of carbon dioxide in confined spaces. The danger of suffocation exists in confined spaces unless special breathing apparatus is available.

Even under normal conditions, fire aboard a Navy vessel at sea can cause more fatalities and injuries to personnel and damage to the ship than

those resulting from battle. To know and understand the dangers of fire is extremely important for all personnel.

GENERAL MAINTENANCE

Back home you may have kept your old jalopy running by puttering with it in all your spare time and learning from your mistakes. You have seen enough torpedo tubes and test equipment with their complex and powerful but sensitive machinery to know that modern weapons require special skill to maintain. Mistakes can be too costly in personnel and money to take a chance. You cannot just turn loose eager beavers with screwdrivers and leave it to their ingenuity to do a maintenance job.

Some maintenance jobs must be done more often than others. The Navy uses maintenance requirement cards (MRCs) (fig. 5-1), in the Planned Maintenance System (PMS) to make sure that routine maintenance jobs are done at the required regular intervals (weekly, daily, monthly, etc.) and that no steps are forgotten.

You will obtain the MRCs from your work center supervisor. The MRCs will then become a guide when doing the work. These MRC's specify all the routine maintenance jobs that are required for a given torpedo or piece of test equipment, leaving as little as possible to the imagination. The individual maintenance items for tasks are classified by frequency—how often they are to be done.

Daily maintenance is concerned mostly with lubrication and inspection. On a torpedo this might be a visual inspection for Otto Fuel II leaks and on the torpedo tube it might be checking the sight glass for any evidence of leakage. To do the lubricating, you must have the lubrication chart (there may be several) for that piece of equipment.

PREVENTIVE MAINTENANCE

There are two main classes of maintenance work. The most important, which accounts for most of the maintenance work you do, is preventive maintenance. The purpose of preventive maintenance is not so much to repair troubles and malfunctions as they arise, but to prevent them before they appear. Preventive maintenance is based on the well-known principle that an ounce of prevention in the form of adequate routine maintenance is worth a pound of cure in the form of repair.

SHIP SYSTEM	SUBSYSTEM	MRC CODE SO-13 W-3	
SYSTEM	EQUIPMENT AN/SQS-23D,E,F,G Sonar Detecting- Ranging Set	RATES STG3 STGSN	M/H 0.4 0.4
MAINTENANCE REQUIREMENT DESCRIPTION 1. Clean and inspect record/reproduce heads and vacuum pads of performance monitor equipment (PME). 2. Demagnetize the record/reproduce heads. 3. Test operate PME.		TOTAL M/H 0.8 ELAPSED TIME 0.4	
SAFETY PRECAUTIONS 1. Forces afloat comply with Navy Safety Precautions for Forces Afloat, OPNAVINST 5100 series.			
TOOLS, PARTS, MATERIALS, TEST EQUIPMENT			
MATERIALS 1. [1608] Brush, paint, sash and trim 2. [0063] Applicator, disposable, cotton tip, wood		3. Tape, blank PME MISCELLANEOUS 1. [2360] Cleaner, magnetic tape head	
NOTE: Numbers in brackets can be referenced to Standard PMS Materials Identification Guide (SPMIG) for stock number identification.			
PROCEDURE Preliminary a. Turn PME POWER on. b. Remove recording tape from PME. c. Turn PME POWER off.		PAGE 1 OF 2	
1. Clean and Inspect Record/Reproduce Heads and Vacuum Pads of Performance Monitor Equipment (PME). a. Moisten cotton swab with head cleaner. b. Wipe record/reproduce heads with moistened swab. c. Clean record/reproduce heads with dry swab. d. Brush vacuum pads with stiff-bristle brush. e. Inspect main capstan record/reproduce heads for scratches. f. Inspect metering wheel for concentric rotation.			
2. Demagnetize the Record/Reproduce Heads. a. Plug head demagnetizer into AC outlet. b. Place demagnetizer tips lightly in contact with record/reproduce head, with prongs straddling the center ridge of head. c. Slowly move demagnetizer back and forth four times.		43 BBV7	
LOCATION	DATE April 1991		N

MAINTENANCE REQUIREMENT CARD (MRC)
OPNAV 4790-82 (REV. 2-82)

Figure 5-1.-Maintenance Requirement Card.

Preventive maintenance is not dramatic or exciting. There is no glamour in a grease gun, but taking a little trouble and time to do the preventive routine maintenance now will save a lot of trouble and time later by heading off breakdowns and time-consuming repairs.

Your preventive maintenance work may be very much like that of a coach who is assigned to keeping a team of highly trained athletes in top fighting form. For both TMs and machines, it is daily attention to details that is important. For machines, these details are things like inspection, lubrication, and tightening and adjusting of parts.

To let any of those things go means trouble, just as there is trouble for an athlete who decides to break training.

CORRECTIVE MAINTENANCE

In spite of the best preventive maintenance, sometimes your equipment will malfunction or break down altogether. Then it will need corrective maintenance—the urgent repair or overhaul work required to get it into working order. Effective routine maintenance will keep this kind of work to a minimum, but

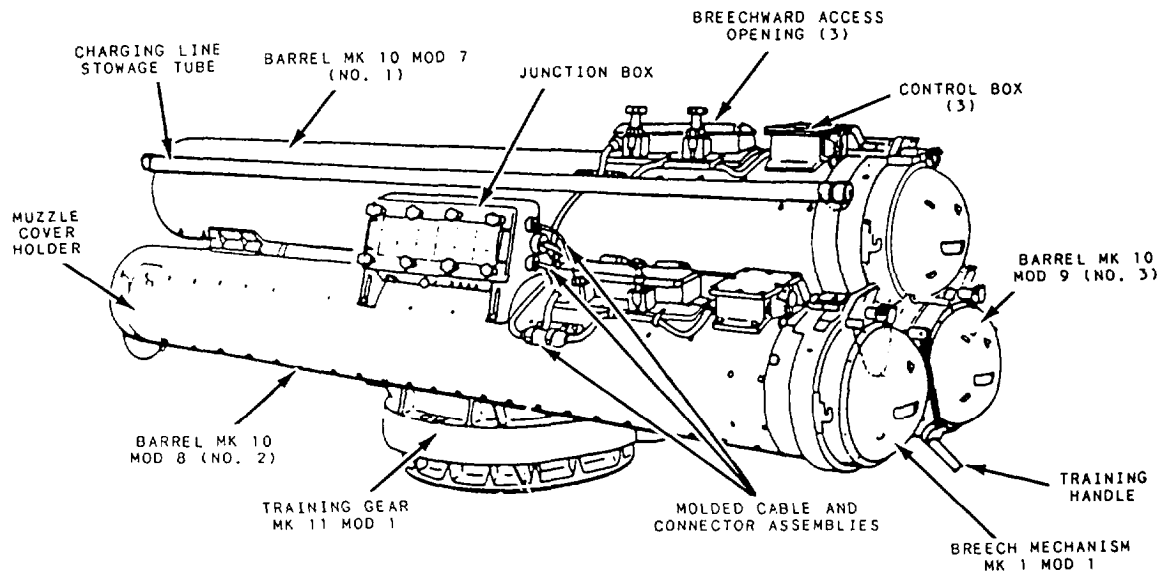
there are times in battle when you must expect casualties and breakdowns and must be prepared to deal with them.

The more you know about how your equipment works, the better you will troubleshoot and repair it. Experience is a great teacher, but you cannot wait until your torpedo or test equipment breaks down in battle to find out how to repair it. Studying the troubleshooting methods and repair techniques will give you the background

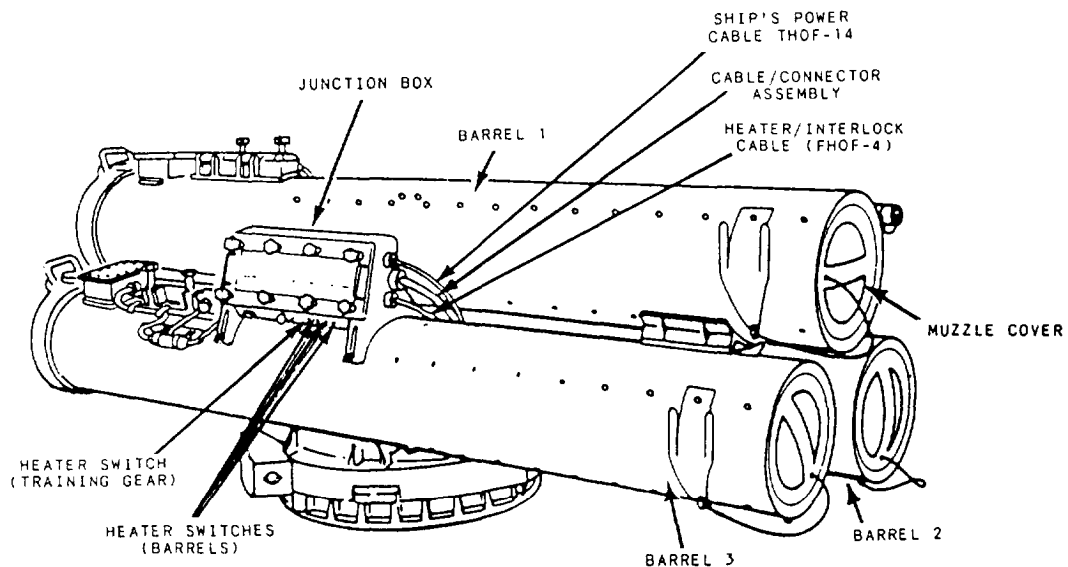
you need to combine with practice to make you an efficient repairman.

MECHANICAL MAINTENANCE

The area that you will be doing most of your mechanical maintenance will be the torpedo tubes. So, let's discuss the maintenance for the torpedo tubes located on both submarines and surface vessels.



SVTT MK 32 MOD 5 AND 7 STARBOARD MOUNT



SVTT MK 32 MOD 5 AND 7 PORT MOUNT

Figure 5-2.-Surface Vessel Torpedo Tube Mk 32 Mods 5 and 7.

TORPEDO TUBE MAINTENANCE

Various weapons will come and go, but the one system that will remain is the torpedo tubes. If they do not operate properly, no matter how high tech your weapons are, they will be rendered useless. Therefore, the most important piece of equipment that you will be responsible for maintaining is the torpedo tubes.

Now, that we know the difference between preventive and corrective maintenance,

why don't we apply it to the surface torpedo tubes.

Surface Vessel Torpedo Tube Maintenance

Surface vessel torpedo tubes are either the trainable type or the fixed (stationary) type. The maintenance of the different types are basically the same. The Mk 32 Mods 5 and 7 (fig. 5-2), 14 (fig. 5-3), and 15 are trainable and the Mk 32 Mod 9 (fig. 5-4) is fixed.

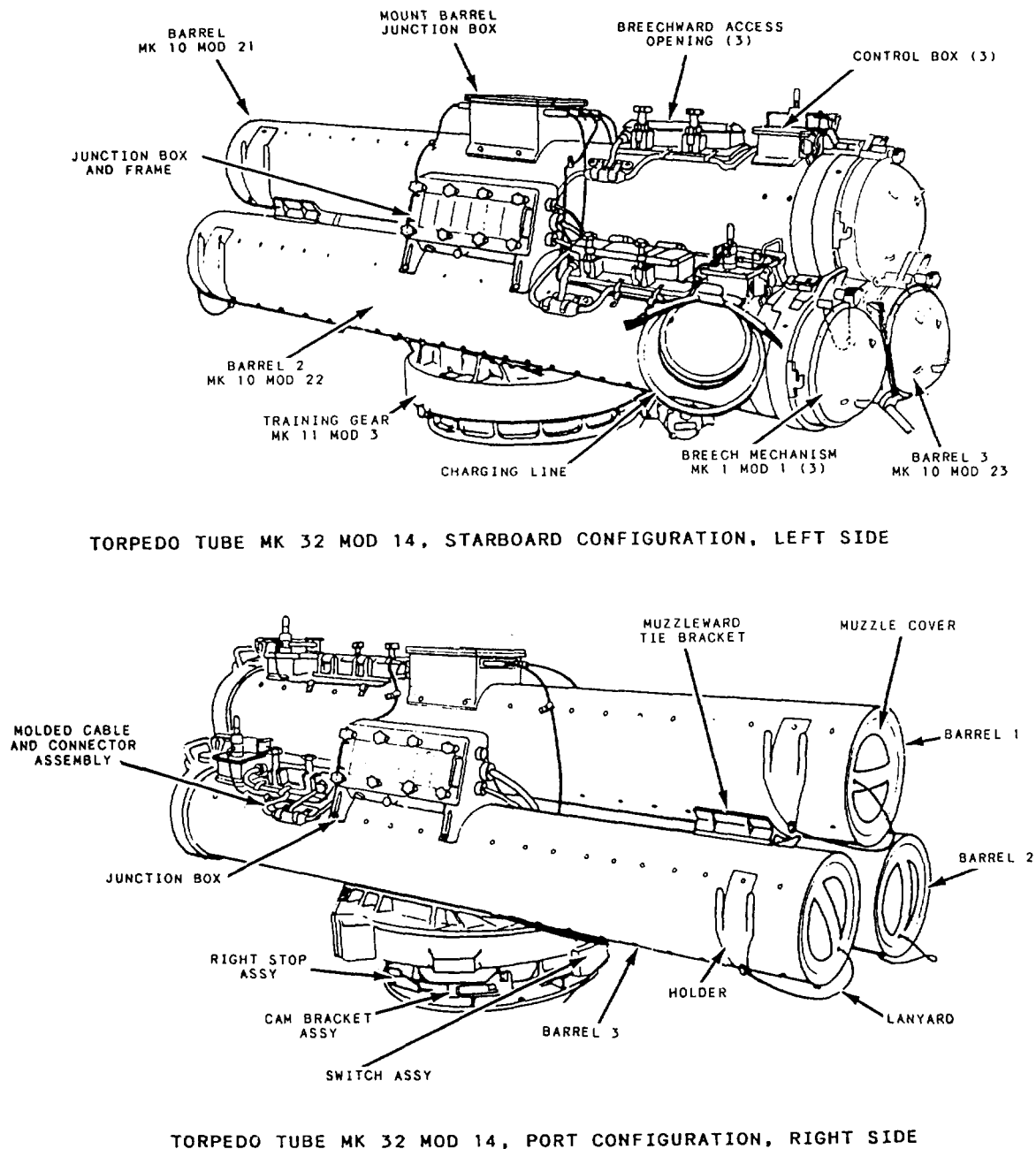


Figure 5-3.-Surface Vessel Torpedo Tube Mk 32 Mods 14 and 15.

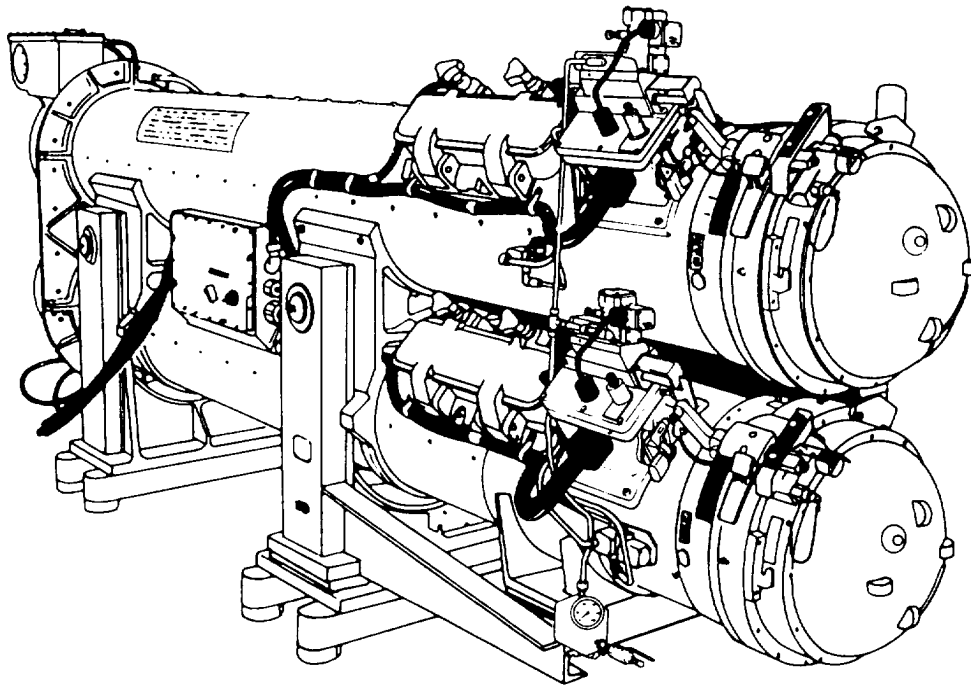


Figure 5-4. Surface Vessel Torpedo Tube Mk 32 Mod 9.

What we need to do now is introduce you to some of the consumables and special tools required to perform maintenance on surface vessel torpedo tubes.

Table 5-1 list consumables which are items such as lubrication supplies, and gaskets. Table 5-2 list those items needed in addition to normally supplied tools.

Before you start to work on any surface vessel torpedo tube perform the following procedures:

1. Shut down all power to the tube and tag applicable switches.
2. Remove the muzzle cover.
3. Bleed the air pressure from the breech mechanism and remove it from the barrel.
4. Remove the securing mechanisms.
5. If the barrel is loaded, train the tube to the unloading position and unload the torpedo.

As we discussed earlier in this chapter, preventive maintenance consist of periodic inspection, cleaning, lubrication and operational testing of the torpedo tube. Since preventive maintenance is accomplished in accordance with PMS, and the procedures outlined on the applicable MRCs, we will not attempt to go into specific maintenance requirements.

What we will do is to introduce you to some of the corrective maintenance that will be required from time to time.

The purpose of corrective maintenance on surface torpedo tubes is to correct existing or probable system or component malfunctions, including maintenance of records and spare parts. Corrective maintenance consists of troubleshooting for fault isolation and replacement of components.

You should observe the following general procedures when preparing tubes for fault isolation, component tests, and corrective maintenance:

1. Keep all parts clean and free from all foreign matter.
2. Protect all working surfaces from damage.
3. Cover all openings in pneumatic systems with heavy paper or tape to prevent the entrance of foreign material.
4. Handle all gaskets and seals with care; discard all those that are damaged or worn.
5. Check that all vent and bleed openings are free of obstruction.
6. Coat threads with antiseize compound, unless otherwise specified.
7. Lubricate o-rings lightly with grease.
8. Clean disassembled parts and mating surfaces with cleaning solvent.

Table 5-1.-Consumables

ITEM	NOMENCLATURE	IDENTIFICATION
1	General Purpose Grease	MIL-G-81322
2	Leak Detection Compound, Oxygen Systems, Type 1	MIL-L-25567
3	Antiseize Compound	MIL-T-22361
4	Pneumatic Grease	MIL-G-4343
5	Gun-Slushing Compound	MIL-C-18487
6	Cleaning Solvent	P-D-680
7	Preformed Packing	MS-28778-20
8	Safety Wire	MS20995C41
9	O-ring	AN-6227-15
10	O-ring	AN-6227-4
11	O-ring	MS28775-010
12	Preformed Packing	MS28778-4
13	Masking Tape	PPP-T-42C
14	Pretreatment Primer	MIL-C-15328
15	Clear Yellow Primer	TT-P-1757 CLR Y
16	Haze Gray Enamel	TT-E-490
17	Insulating Varnish	CLR 26270
18	Filter	MIL-V-1137
19	Nylon Washer	1404007
20	O-ring	1621223
21	O-ring	MS28778-4
22	O-ring	MS28778-10
23	O-ring	AN6227-14
24	O-ring	AN6227-7
25	Epoxy Adhesive	AN6227-11
26	Aluminum Oxide Abrasive Cloth	EC1838A & B
a.	Type I, Class 1, Grit No. 100	P-C-451
b.	Type I, Class 1, Grit No. 80	
c.	Type I, Class 1, Grit No. 40	
27	Flint Abrasive Paper Class 2, Medium Grit	P-P-105
28	Deleted by Change B	
29	Methyl Ethyl Ketone	TT-M-261
30	Acetone	O-A-51
31	Cleaning Solvent	MIL-C-18718
32	Adhesive	MMM-A-121
33	Oil, General Purpose	MIL-L-17672
34	Rust Preventive Compound	MIL-C-16173 GR11
35	Isopropyl Alcohol	TT-I-735 Type A
36	Adhesive, Sealant, RTV	MIL-A-46106
37	Seal, Static Pressure	Type 1
38	Adapter, wire size 14-16 to 18-20	5758483
39	Crimp Splice	2844113
		M7928/3-3

Table 5-2.-Special Tools and Equipment

NOMENCLATURE	IDENTIFICATION NO.
<ol style="list-style-type: none"> 1. Multimeter 2. Megger 3. Heat Gun 4. Regulator 5. *Firing Valve Removal Tool 6. Grease Gun 7. Soldering Gun 8. Inserting/Extraction Tool 9. Bar, Thermoswitch Removal 10. Oiler, Hand 11. Nipple, Quick Connect 12. Applicator - 5 Ft Tubing with 1/4 or 1/8 NPT End Fitting to Suit Standard CO² Bottle 13. *Power Unit, Hydraulic 14. Test Set Mk 432 Mod 2 (used in conjunction with applicable fire control system MRCs) 15. Pressure Beam 	<p>AN/PSM-4 AN/PSM-2 1473467 87-1500-580 3015012 MIL-G-1330-72 41G1865-450 MIL-1-81969/14A-03 3245016 MS15764-1 1404077</p> <p>1623864</p>
<p>*Indicates items available on tenders</p>	

During fault isolation, you, the technician will use specified test procedures to determine the area of the malfunction. Table 5-3 is a example of what a fault isolation chart will look like. These charts can be used in analyzing major malfunctions. To avoid any unnecessary disassembling, you should perform a systematic analysis of the malfunction to determine the specific cause and take corrective action as required. Refer to disassembly or repair procedures as applicable.

Fault isolation and corrective repair procedures are listed in applicable technical manuals. Technical manual SW395-AC-MMO-010/OP 3355 applies to the Mk 32 Mods 5 and 7 surface vessel torpedo tubes, technical manual SW395-AD-MMO-010/Mk 32 Mod 9 applies to the Mk 32 Mod 9 surface vessel torpedo tubes, and technical manual SW395-AE-MMO-010 applies to the Mk 32 Mod 14 surface vessel torpedo tubes.

To ensure system integrity after corrective maintenance, you should do general maintenance and/or conduct operational tests. Refer to the applicable maintenance index page (MIP) for a listing of the different procedures.

Your job, as a maintenance person, would not usually require you to completely disassemble or reassemble the torpedo tube. Though some jobs are more complex than others. For example, either replacement or repair procedures, or both, for a SAFE/READY solenoid valve or a SQUID FIRE switch are not routine maintenance. However, replacement of most gauges are relatively routine. To give you an idea of what is involved in this type of maintenance, let's discuss these two evolutions.

Let's start with the replacement of the SAFE/READY solenoid. Before beginning any job, you must always perform the general procedures that we discussed earlier: shutting down power, removing muzzle covers, bleeding down air flask, removing securing mechanisms and unloading torpedo tubes if loaded. After removing the cover of the control box, ensure that no voltage exist. Disconnect the switch lead and cut it from the pressure switch close to the splice and remove the switch. Verify that you have the correct replacement switch, lubricate it with the applicable grease, and install a new o-ring. Then install the new switch verifying operation with the

Table 5-3.-Fault Isolation

SYMPTOM	PROBABLE CAUSE	TEST/REMEDY
No BARREL READY indication at Fire Control	Lever of control valve operating mechanism in muzzleward (STANDBY) condition	Shift lever to breechward position.
	Flask pressure below minimum 1275 psig	Recharge or see Symptom Breech Mechanism leak.
	Defective Pressure Switch S109	Perform continuity check, refer to electrical schematic, and replace.
	Defective READY LIGHT Switch S101	Perform continuity check, refer to electrical schematic, and replace.
	Defective Sector Clear Switch S106	Perform continuity check, refer to electrical schematic, and replace.
	Defective wiring in ready circuitry	Check Barrel Ready circuit, refer to ship functional and electrical schematic, and repair.
Barrel in READY condition fails to fire electrically but will fire manually	Defective electrical firing circuit	Check firing signal from fire control, refer to ship functional and electrical schematic, and repair.
	Defective solenoid valve	Check firing circuit, refer to electrical schematic, and repair. Perform continuity check, refer to electrical schematic, and replace.
Barrel in READY condition but fails to fire electrically or manually	Defective control valve causing a drop in pressure	Check for leakage. Replace or repair defective valve.
	Flexible hose not connected	Connect flexible hose.
	Defective securing mechanism	Perform applicable MRC(s). Replace or repair defective units.
	Defective solenoid valve	Perform applicable MRC(s). Replace or repair defective valve.
	Defective plug puller mechanism	Perform applicable MRC(s). Replace or repair defective units.
	Air lines clogged	Disconnect air line and blow clean.

Table 5-3.-Fault Isolation—Continued

SYMPTOM	PROBABLE CAUSE	TEST/REMEDY
Barrel fires prematurely when lever of control valve operating mechanism is moved breechward without an electrical fire signal or manual fire actuation	Solenoid valve open, possible defective, or electrical defect causing solenoid to be energized	Perform applicable MRC(s). Check electrical circuitry, refer to ship function and electrical schematic. Replace or repair defective solenoid.
Barrel Heater Failure	Defective wiring	Perform applicable MRC(s). Replace or repair defective component.
	Defective Heater Switch S110, S111, or S112	
	Defective Thermoswitch S102 or S103	
	Defective heater element	
Training Gear Heater Failure	Defective wiring	Perform applicable MRC(s). Replace or repair defective component.
	Defective Heater Switch S104	
	Defective Thermoswitch S107	
	Defective heater element	
High Temperature Alarm and Supervisory Circuit Failure	Defective wiring	Perform applicable MRC(s).
	Defective Thermoswitch S113 or S114	
	Defective coil in Barrel Heater Relay K1	
Breech Mechanism and Pneumatic System Leak		Perform applicable MRC(s).
a. Leaking Pilot Tube	Defective O-rings in control valve	Replace or repair control valve.
b. Leaking Firing Valve	Defective O-rings	Replace O-rings.
c. Leaking Charging Nipple	Broken valve spring, defective valve seat, or defective internal O-ring	Replace or repair charging nipple.
d. Leaking around body of Charging Nipple	Defective gasket	Replace gasket.

use of an ohmmeter. Reinstall the control box cover, and perform the applicable MRCs and return the equipment to normal condition.

The other example we will discuss is the replacement of the emergency squib fire switch. Again, you must perform the general procedures described in our last paragraph. First, remove the cover to the control box and disconnect the switch lead at the terminal board. Then, remove the old switch and install the new one on the bracket. With the lever in the secured position, adjust the position of the switch so that .010 of an inch clearance exists between the end of the switch plunger and the terminal board. After reinstalling the control box cover, perform the applicable MRCs and return the equipment to normal condition.

These checks are only two of many that are performed on a continuous basis. For more information on the checks and requirements for the surface vessel torpedo tubes, review your MRCs in the work center.

Now, let's briefly talk about submarine torpedo tube maintenance.

Submarine Torpedo Tube Maintenance

Submarine torpedo tubes vary depending on the type and class of submarine. The major differences lie in the physical mounting arrangement. Because we will not be addressing this subject at any great depth, the maintenance will be similar for all of the different Mk and Mods of torpedo tubes. The submarine torpedo tubes we will summarize are the Mk 63 (fig. 5-5), Mk 65 (fig. 5-6), Mk 67 (fig. 5-7), and Mk 68 (fig. 5-8).

As with the surface torpedo tubes, the submarine torpedo tube preventive maintenance is accomplished in accordance with PMS, and the procedures are outlined on the applicable MRCs, so we will not attempt to go into specific maintenance requirements.

Instead, let's discuss the major types of preventive maintenance that you as a Torpedoman will do on an almost daily basis: inspecting and cleaning, and lubrication.

You must inspect and exercise working parts at every opportunity to detect and correct possible causes of failure. Examine the stop mechanism and interlocks for deformation and lost motion and check that they operate properly. Electrolytic action can occur when dissimilar metals are

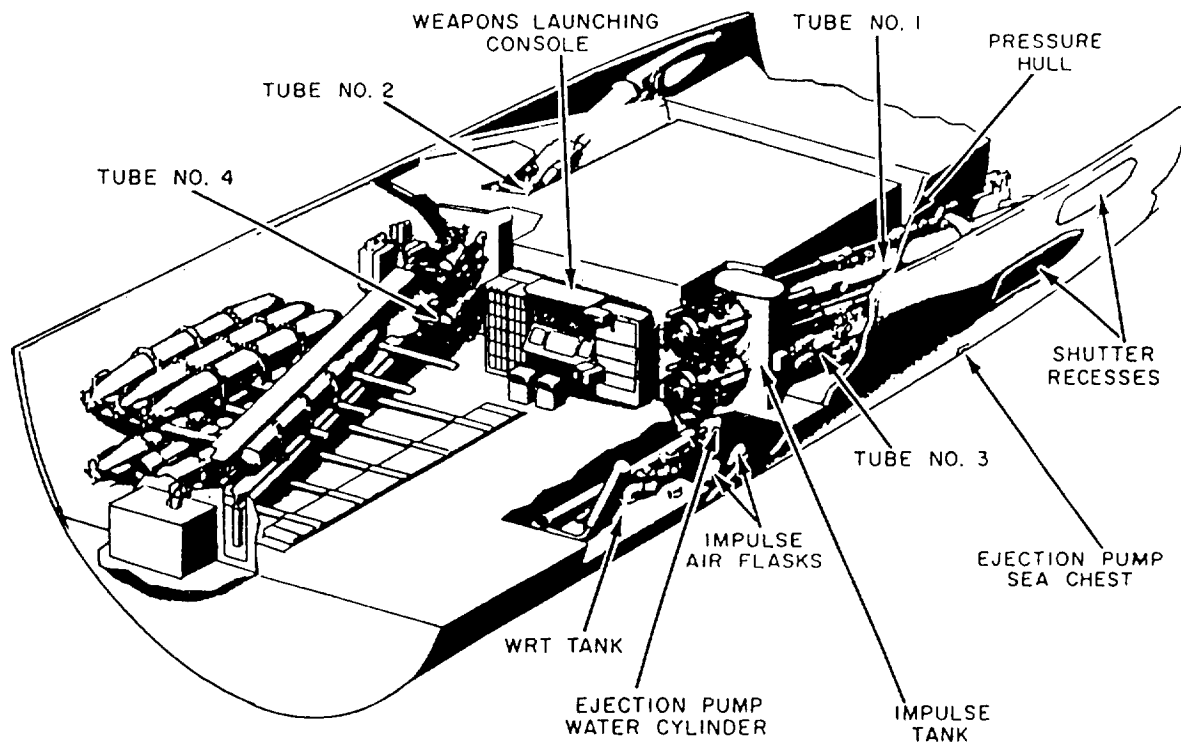


Figure 5-5. Submarine Torpedo Tubes Mk 63.

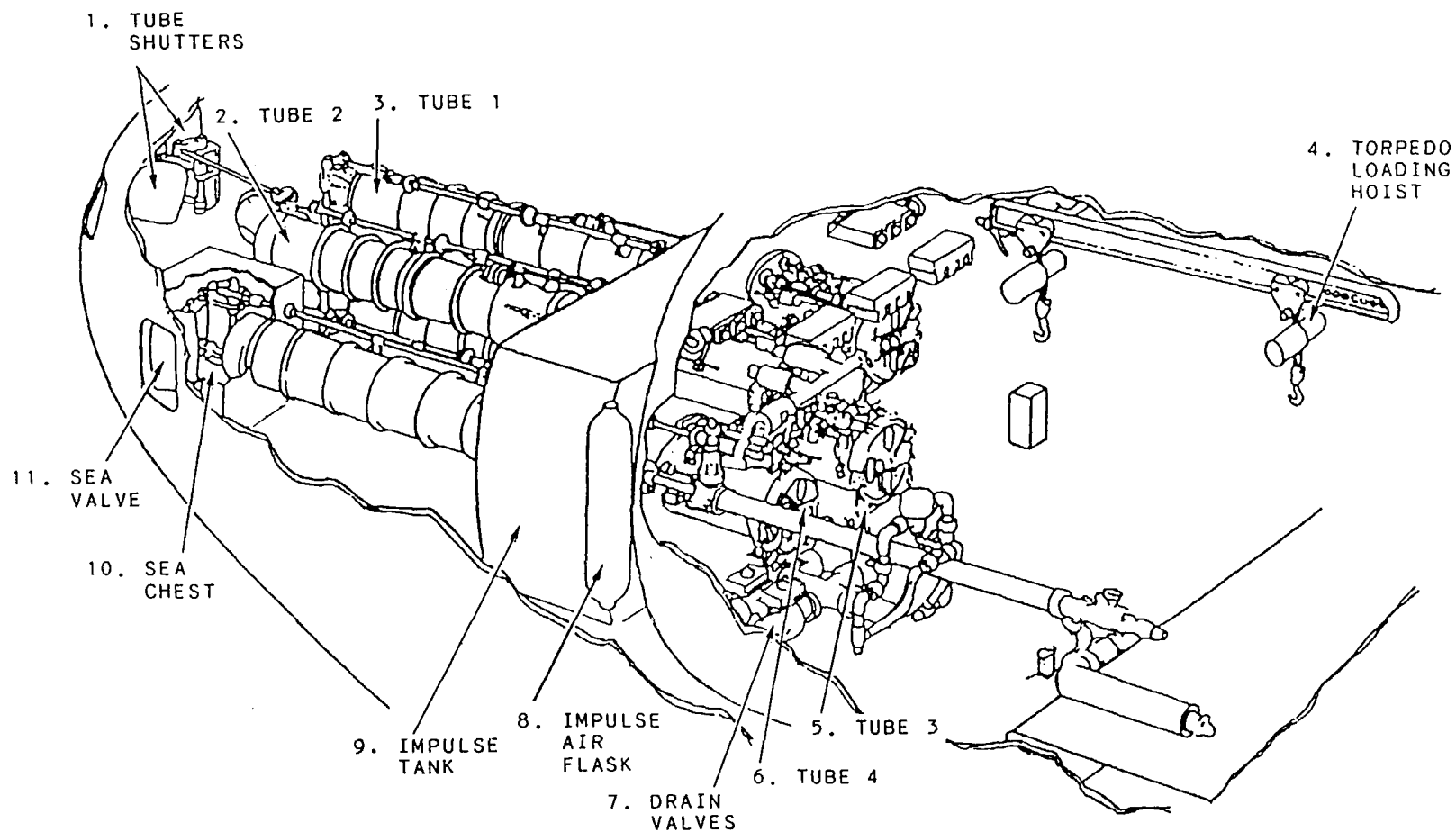


Figure 5-6.—Submarine Torpedo Tubes Mk 65.

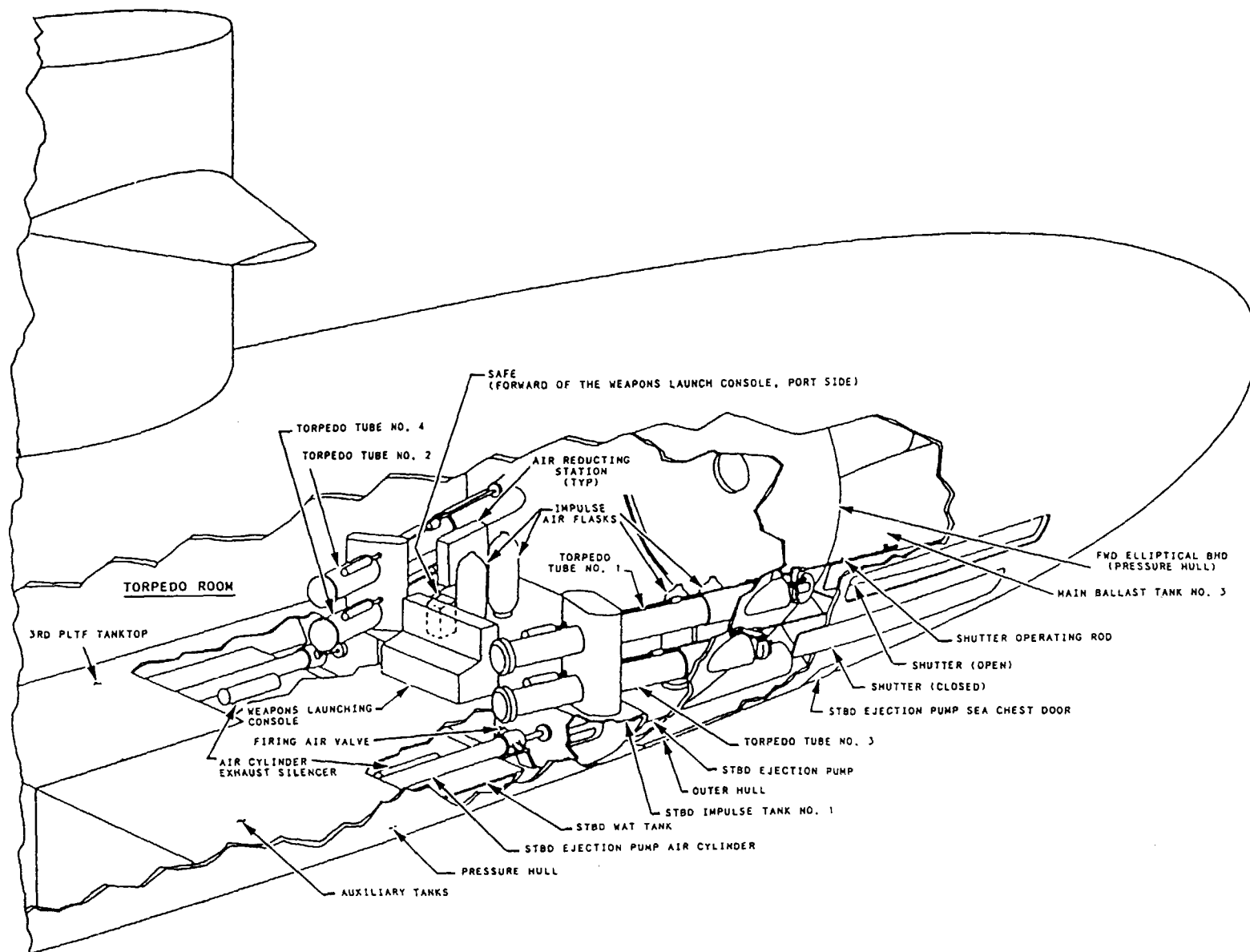


Figure 5-7.—Submarine Torpedo Tubes Mk 67.

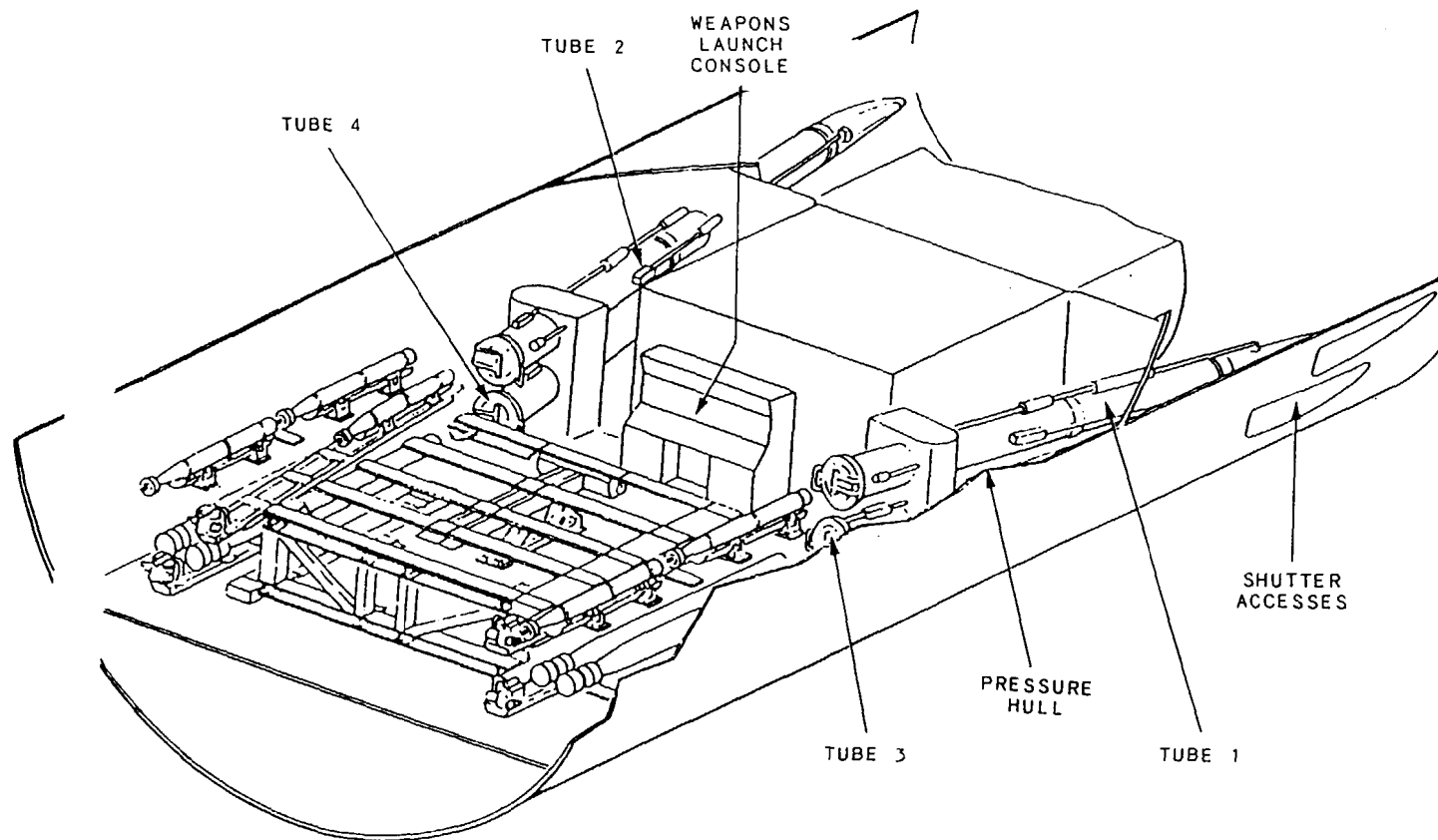


Figure 5-8.—Submarine Torpedo Tubes Mk 68.

exposed to sea water. You should keep tube components clean and dry whenever possible.

You must lubricate torpedo tubes and associated components periodically in accordance with the MRCs, using only the proper lubricants. Whenever practicable, exercise components while lubricating. Remember, some lubricants that are satisfactory for steel may corrode bronze or other materials, especially when combined with brine. Some oils thicken, harden, and lose their lubricating qualities when affected by salt and moisture. OD 3000 provides additional information on lubricants, fluids, cleaning and preserving materials, cold weather lubrication, and ordering data.

The purpose of corrective maintenance on a submarine is the same as on a surface vessel: to detect and correct the malfunction. Procedures for troubleshooting, adjustment, disassembly, repair and replacement of components are included in applicable technical manuals for each of the torpedo tubes.

Submarine launching system repair\maintenance actions are divided into three categories: Category A, Category B, Category C.

Category A is any repair or maintenance action accomplished by replacing o-rings, gaskets, incidental hardware (cotter keys, lockwashers, etc.), replacement of calibrated pressure switches, or addition of fluids and lubricants.

Category B is any repair or maintenance action that requires replacement of valve stems, seats, plungers, bodies, complete valve assemblies or fluids. Additionally the adjustments to firing valves, firing control valves, throttle valves, air restrictor valves, and metering valves are also considered Category B.

Category C is any major overhaul or modification action performed by a qualified repair activity, during extended refit period (ERP), shipyard refit availability (SRA), ordnance alterations, etc.

The three most common types of corrective maintenance that you will be concerned with are troubleshooting, adjustments, and component repair.

Table 5-4, is an example of a list of possible tube and component malfunctions, with probable

Table 5-4.-Possible Tube Malfunctions

Symptom	Probable Cause	Remedy
Torpedo tube leaks	1. Nuzzle door not shut	a. Position muzzle door control valve to shut. b. Check adjustment of muzzle door mechanism giving special attention to excessive lost motion. Check that operating cylinder piston travels its full stroke.
	2. Loss of hydraulic pressure to muzzle door operating cylinder	a. Put hand pump on line and use to supply shutting pressure to muzzle door until cause of loss of normal pressure can be located and corrected.
	3. Muzzle door fouled by debris	a. Cycle door open and shut several times to clear debris and allow proper seating of muzzle door. b. Open muzzle door and fire water slug.
	4. Slide valve fouled by debris	a. Open muzzle door and fire water slug to clear tube barrel.
	5. Slide valve operating mechanism out of adjustment	a. Check operating linkage between slide valve and muzzle door. Readjust as required to shut slide valve fully.
	6. Slide valve gaskets worn or damaged	a. Remove and replace defective gaskets.
	7. Drain valve fouled by debris	a. Open drain valve and blow through from tube to WRT tank.

Table 5-4. Possible Tube Malfunctions—Continued

Symptom	Probable Cause	Remedy
Torpedo tube leaks (Continued)	7. Drain valve fouled by debris (Continued)	b. The preceding failing, reverse blowing (from WRT tank to tube), shutting drain valve during blowing. c. Both preceding remedies failing, disassemble, clear, and re-assemble drain valve.
	8. Tripping latch leaks	a. Observe same precautions as for <u>Slide valve gaskets worn or damaged</u> . b. Drain impulse tank, open slide valve (disconnect from operating mechanism), remove upper protective grills, and tighten hold-down bolts on tripping latch housing inside impulse tank.
	9. Muzzle door gasket leaks	a. Replace gasket (in drydock).
No relay hold voltage at switchbox P1 pins <u>w</u> and <u>z</u>	1. Stop bolt switch out of adjustment	a. Adjust stop bolt switch so that contacts are closed when stop bolt is at LOAD and FIRE; open at LOCKED.
	2. Electrical firing circuit failure	a. Check power on. b. Check fuses on silent fire and miscellaneous fuse panel.
	3. Faulty stop bolt switch	a. Replace switch with a spare.

causes and remedies. It can be used as a troubleshooting guide, but it does not come close to covering every possible malfunction. If the trouble cannot be located and remedied using the data from table 5-4, a step-by-step inspection of the system components must be initiated.

During normal operation of the torpedo tubes, various components can lose their precise adjustment and cause tube malfunction or reduced operating efficiency. Standard mechanic's tools are carried onboard for adjustment of the tube mechanism and associated components. Special tools are illustrated in specific technical manuals for the Mk and Mod of torpedo tube involved along with the adjustment procedures.

An example of an adjustment you might do would be the hand firing key and transfer switch.

If an electrically started, impulse launched torpedo fails to start when the hand firing key is positioned at FIRE, an incorrect adjustment of the hand firing key and transfer switch may be the cause. To correct this malfunction, turn the adjusting screw on the hand firing key so that when the key is moved to fire, motion of the transfer switch to EMER POWER is simultaneous with, or slightly before, opening of the firing key valve.

Component repair procedures are specific to particular Mk and Mod's of torpedo tubes. Because of the many variations in configuration, all repairs should be made using their specific technical manual.

The other area of maintenance that you will need to be familiar with is electrical maintenance. So, let's get started and discuss what you might encounter in electrical maintenance.

ELECTRICAL MAINTENANCE

There are many electrical and electronic circuits used in ordnance equipment. These circuits perform such jobs as automatic or local control, stabilization, amplification, and overload protection. It is beyond the scope of this chapter to examine each type of circuit individually, but fortunately there is a shortcut. All electrical circuits use basic electrical or electronic devices. These devices, individually or working together, can delay, interrupt, isolate, or integrate electrical and electronic circuits and prevent damage to equipment.

Let's take a little time to discuss some of the main elements of an electrical circuit so you will be able to relate to them when you have to perform maintenance on your equipment in the fleet.

CIRCUIT ELEMENTS

This portion of the chapter covers some of the more common electrical devices used in the ordnance circuits that you will be working with.

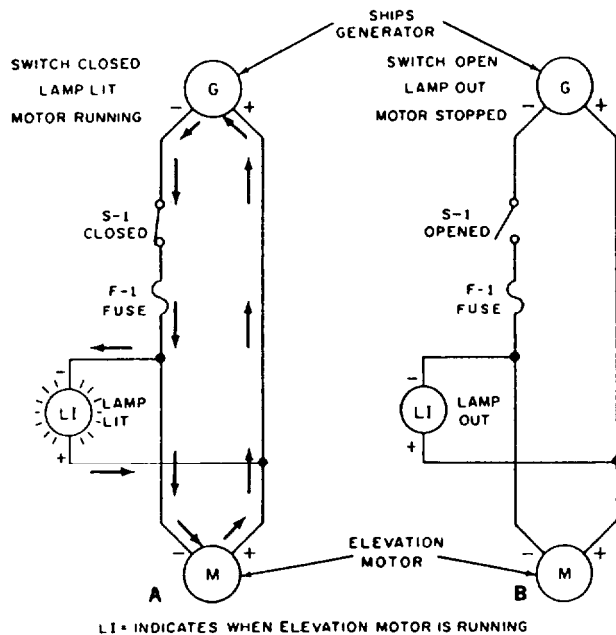


Figure 5-9.-Indicator lights.

Indicator Lights

Indicator lights are used to indicate the position or status of switches, solenoids, fuses, and control and power circuits. Figure 5-9 shows a simplified circuit with a light (L1) that indicates when the motor is running. The L or L1 is a reference designation for lights on the schematics for the older systems; the designation for lights on schematics for new ordnance equipment is DS.

Fuses

The fuse (fig. 5-10) is the simplest form of a circuit protective device. It consists of a metal alloy fusible element that melts at a predetermined value of current. Thus, if a circuit draws more current than the rated value of the fuse, the fuse opens (blows) and the circuit components are protected.

Fuses are rated according to the amount of current they can safely carry; this current is usually measured in amperes. The most common cause of fuse failure is an overloaded circuit. There are, however, other causes. Failure to set the fuse into its contacts properly can cause a fuse to open. The schematic designator for a fuse is the letter F.

Switches

A switch is a device used for making, breaking, or changing the connections in an electric circuit. Switches are used to start and

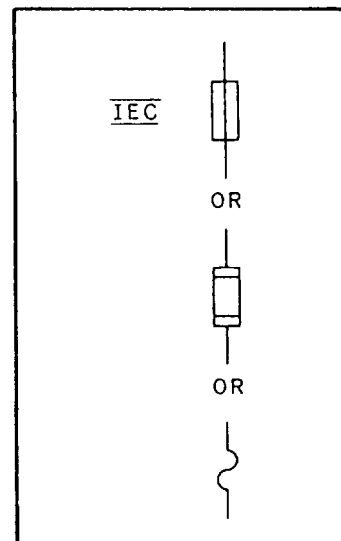


Figure 5-10.-Fuse.

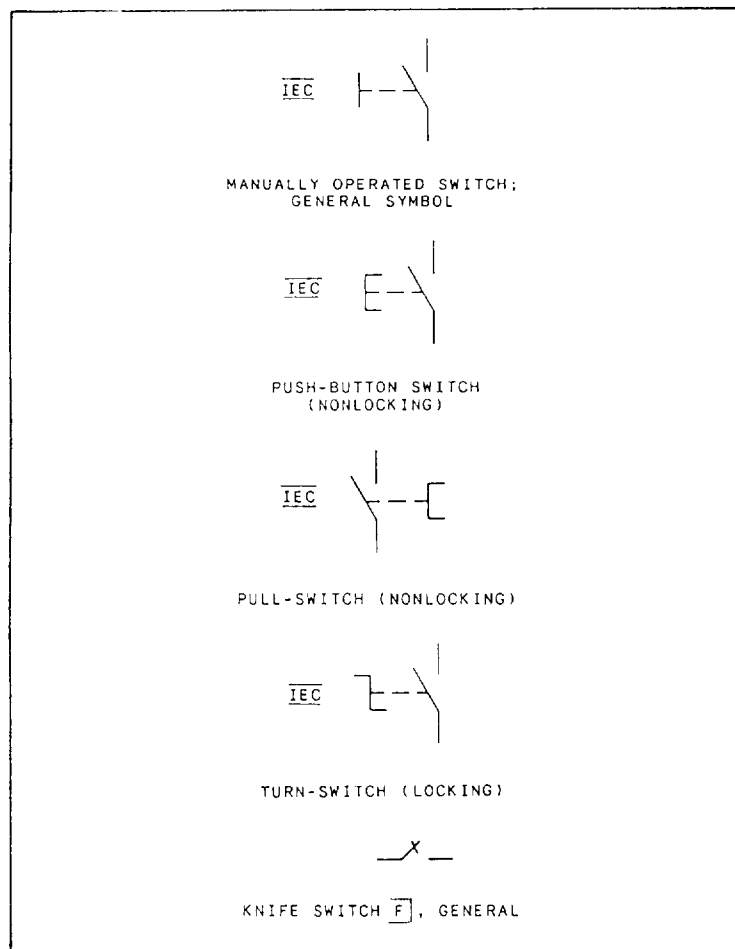


Figure 5-11.-Switches.

stop motors, to turn indicating lights on and off, to channel information from one point in the system to another, and to shift system mode of operation, to name a few of their many uses.

Switches are frequently classified by the number of poles, by the throw, or by the number of positions they have. Another way of classifying switches is by the method of actuation; that is, pushbutton, toggle, rotary, and the like. Switches can also be classified by using the trade name of the manufacturer. Figure 5-11 shows an example of four different switches. The designator for switches on a schematic is the letter S.

Relay

A relay is simply an electromagnetically operated switch. It is designed to open or close a circuit when the current through its coil is applied and removed, or varied in magnitude. The

main parts of a relay are a coil wound on an iron core and an armature that operates a set of contacts. A simple relay and circuit are shown in figure 5-12. The schematic designator for a relay is the letter K.

Solenoids

Solenoids convert electrical inputs from control circuits into mechanical outputs that actuate

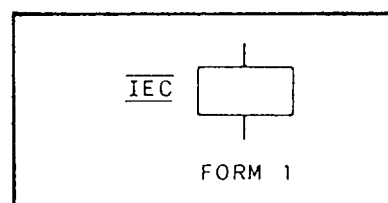


Figure 5-12.-Relay.

mechanical linkage or hydraulic valves. The schematic designator for a solenoid is the letter L.

Now that we have introduced you to the circuit, let's talk about where your role in maintenance will come into play. Normally that will be when you have experienced a failure of a circuit either in the torpedo, the torpedo tube or the test equipment.

CAUSES OF CIRCUIT FAILURES

The failure of a circuit to function properly can usually be traced to a break in the circuit (open), a grounded circuit (this permits an undesired path of current return to the source), or a short circuit (a circuit that permits current to bypass a part of the circuit).

Any of these faults affect the current and voltage values and causes the circuit to function improperly.

Open circuits may result from dirty or loose connections, improperly installed wire, mechanical damage, faulty installation or repair, and vibration. If connections are clean and tight, no resistance is added to the circuit.

Short circuits are low-resistance paths or short-cuts that cause the current to bypass the load. The current from the source passes through the "short" instead of the load, causing the load to function improperly. Most shorts are accidental. They occur when vibration wears away the insulation, when saltwater gets into connection boxes, when heat melts away insulation, and when an act of carelessness brings two conductors together.

A grounded circuit is one in which one side of the path is connected to ground either intentionally or accidentally. An intentionally grounded circuit uses a ground which is the ship's hull, equipment chassis, etc., as one side of the line or one conductor. If the "hot side" conductor of a grounded source touches ground accidentally, a short circuit results. Power circuits in the Navy are not grounded and must be insulated from ground at all times. One side of this circuit may be grounded accidentally, and no harm will result; but if both sides are grounded, a short circuit is the result. An ungrounded circuit has a safety feature. If anyone accidentally touches one side of an ungrounded circuit, there will be no path for current flow through the body to the other side of the source. This is one reason why power circuits in the Navy are insulated from ground.

Now I'm sure your next question is, how do I determine what has happened to my equipment? That is where our next area of discussion comes into play: troubleshooting.

TROUBLESHOOTING

Before we discuss the details of troubleshooting, let's establish the basic element of satisfactory troubleshooting—a LOGICAL APPROACH. Because of the complex nature of today's electronic systems, whether military or civilian, the people assigned to keep the equipment operational must have highly specific training. These technicians are not superhuman in their understanding of the electronics maintenance for such devices. What is the secret of technicians who have excellent maintenance capabilities? It is simply that they have learned to think logically. Once you have learned the fundamental theories of basic electronic circuitry, you must learn to combine solid theory and logical thinking to apply troubleshooting techniques. This combination forms a complete maintenance system that you can use to keep equipment operating at top efficiency. By using this system, you will be able to divide electronic equipment into functional blocks; you will be able to test equipment, discover deficiencies, and repair them in an orderly and professional manner. This procedure will save you valuable hours that are otherwise wasted in haphazard troubleshooting techniques.

The Six-Step Procedure

A six-step procedure has been adopted to standardize the approach to electronic equipment troubleshooting and maintenance procedures. This procedure saves many hours of needless equipment downtime and costly repairs. Use of this procedure also keeps electronic equipment in a constant state of operational readiness. The six-step procedure is listed below:

1. SYMPTOM RECOGNITION
2. SYMPTOM ELABORATION
3. LISTING OF PROBABLE FAULTY FUNCTIONS
4. LOCALIZING THE FAULTY FUNCTION
5. LOCALIZING TROUBLE TO THE CIRCUIT
6. FAILURE ANALYSIS

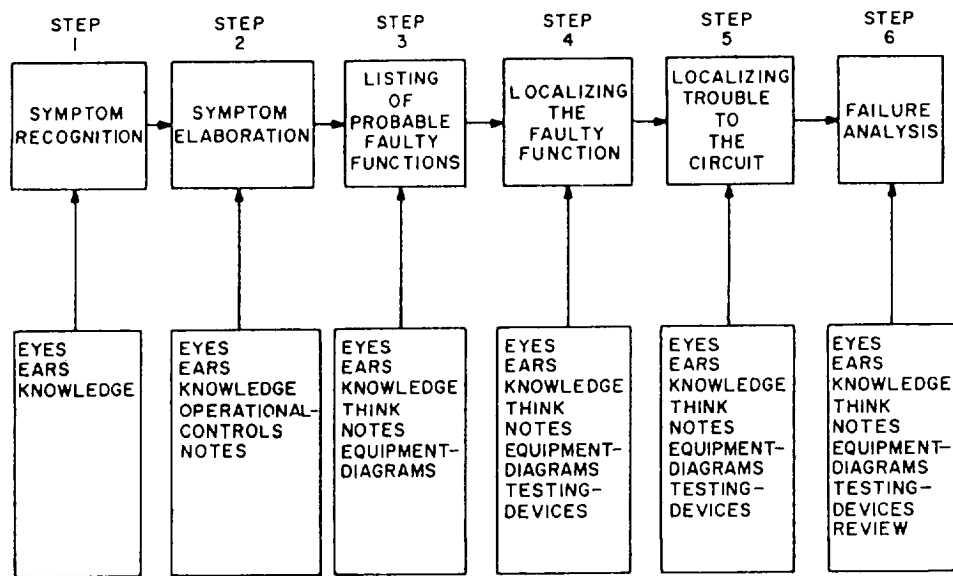


Figure 5-13.-Six-step procedure.

Figure 5-13 shows a breakdown of these steps.

All right, that sounds good, now let's apply it. The first step in logical troubleshooting is to recognize the normal condition of a piece of equipment. In other words, you should know when everything is working properly. Symptom recognition is, therefore, just what it says—the recognition of a situation which is not a normal condition. With this step completed, you are ready for step two, symptom elaboration.

Symptom elaboration is the next logical step once you have detected a malfunction. Most electronic equipments have operational controls, additional indicating instruments, and/or other built-in aids to assist you in evaluating the performance of the equipment. Do not overlook anything. The smallest bit of information you collect at this point may lead to the solution of the problem.

When you have found all of the symptoms of the malfunction, the third step is to list, either mentally or on paper, the possible causes of these symptoms. Many manufacturers' technical manuals list the "probable cause" in the corrective maintenance sections.

After evaluating the symptoms, you have made decisions as to the most likely areas in which the trouble could occur (step three). Armed with a complete set of symptoms and with the probable cause for these symptoms, you are ready for the fourth step of the six-step procedure—localizing the faulty function. This means that you

determine which of the functional units of the equipment is actually at fault. This requires that you use your knowledge of the equipment, as well as technical manuals, notes you have made, and some testing devices. (However, do not use testing devices at the circuit level.) Once you have determined which section of the equipment is malfunctioning, you can move on to step five, localizing the trouble to the circuit.

In this step the use of test equipment is required. You use it to measure or indicate the presence or absence of a signal at various points in the suspected circuit. The signal is traced from its source until lost at some test point. Once you have localized the failure to a specific part of the circuit, you should move on to step six, failure analysis.

During step six of troubleshooting, you should use every method of isolation to discover the faulty part. However, locating the faulty part does not complete step six. You should also determine the cause of the failure. To determine if there are multiple malfunctions, you should consider the effect that the malfunction of the component has on the operation of the equipment. If the component is the probable cause of the abnormal symptoms produced in earlier steps, then you can logically assume that the component is at fault. If not, use your knowledge of electronics and the equipment to determine what other malfunction(s) could also produce the same symptoms and indications.

Let's take a moment to discuss the types of circuit checks we have been discussing and the most common types of devices used to do these checks.

Types of Circuit Checks

There are three basic circuit checks used to locate shorts, grounds, and open circuits within electric and electronic equipment.

1. Voltage (volt) checks
2. Current (amperes) checks
3. Resistance (ohms) checks

Voltage checks reveal the amount of potential force present to move electrons in a circuit.

Current checks show the actual amount of current flowing through the circuit.

Resistance checks tell the resistance characteristics of the circuit; that is, how much opposition the circuit offers to the flow of current.

With the proper use of test equipment, failures in electric and electronic circuits can be detected and isolated to specific components by using one of these three checks.

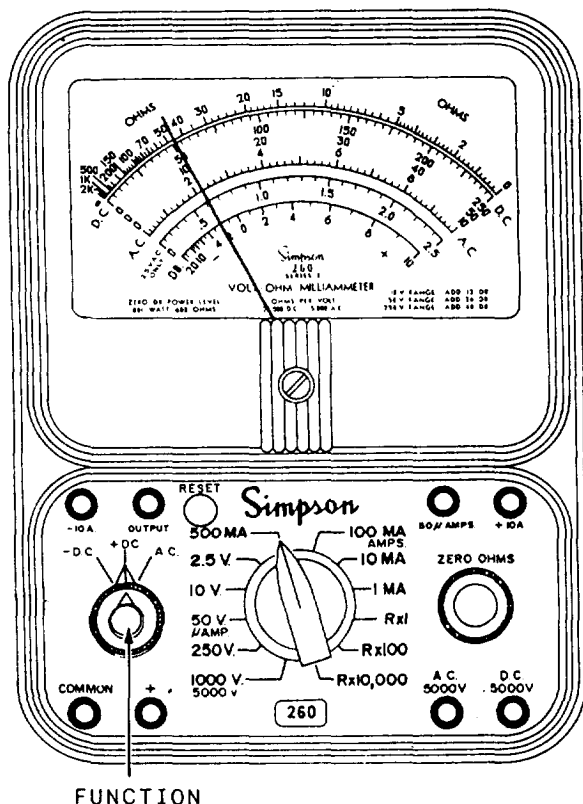


Figure 5-14.-Simpson 260.

Since volts, amperes, and ohms are units of electrical measure, some measuring device must be used to measure them. One device used for this purpose is the multimeter.

The Simpson 260 and the fluke 77\AN are the most commonly used types of multimeters. The Simpson 260 is shown in figure 5-14. It has a large easy-to-read 4-1/2 inch indicating instrument at the top of the front panel. Below the indicating instrument are three operating controls, eight circuit jacks, and the RESET button. All switch positions and circuit jacks are marked with white characters on a black background to ensure long-lasting readability.

Let's discuss one more area of electrical maintenance that you will be involved in from time to time. That is the synchro circuit.

SYNCHRO CIRCUIT

Synchros play a very important role in the operation of Navy equipment. Synchros are found in just about every weapon, communication, underwater detection, and navigation system used in the Navy. The importance of synchros is sometimes taken lightly because of their low failure rate. However, the technician who understands the theory of operation and alignment procedures for synchros is well ahead of the problem when a malfunction does occur.

Figure 5-15 shows a phantom view of a typical synchro. A synchro resembles a small electrical motor in size and appearance and operates like

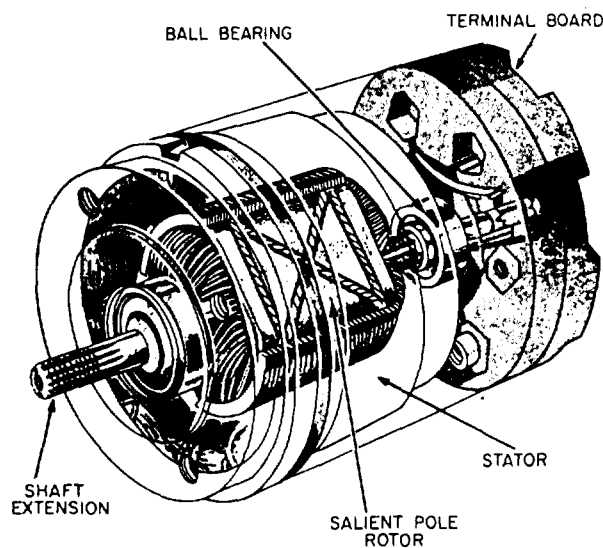


Figure 5-15.-Phantom view of a synchro.

a variable transformer. The synchro, like the transformer, uses the principle of electromagnetic induction.

Synchros are used primarily for the rapid and accurate transmission of information between equipment and stations. The changes in course, speed, and range of targets or missiles, the angular displacement (position) of the ship's rudder, and the changes in the speed and depth of torpedoes are but a few of the numerous kinds of information transmitted. The speed and accuracy of the transmitted information are most important. Synchros can provide this speed and accuracy.

One of your duties as a Torpedoman is to keep the synchro systems in your equipment in good working order. Therefore, it is essential that you become familiar with the details of synchro maintenance and repair.

First, let us consider some of the more common problem areas that you should avoid when working with synchros. As with any piece of electrical or electronic equipment, if it works—let it alone. Do not attempt to zero a synchro system that is already accurately zeroed just because you want to practice. More often than not, the system will end up more out of alignment than it was before you attempted to rezero it. Do not attempt to take a synchro apart even if it is defective. A synchro is a piece of precision equipment, which requires special equipment and techniques for its disassembly. A synchro, unlike an electric motor, does not require periodic lubrication. Therefore, never attempt to lubricate a synchro. Synchros also require careful handling. So, you should never force a synchro into place, never use pliers on the threaded shaft, and never force a gear or dial on the shaft.

Troubles in new and modified synchro systems are most often due to (1) improper wiring and (2) misalignment due to synchros not being zeroed. It is your responsibility to find and correct these troubles. Improper wiring can be checked with an ohmmeter by making a point-to-point continuity and resistance check. Misalignment of a synchro system can be corrected by rezeroing the entire system.

There are various methods for zeroing synchros. Some of the more common zeroing methods are the voltmeter, the electrical-lock, and the synchro-tester methods. The method used depends upon the facilities and tools available and how the synchros are connected in the system. Also, the method for zeroing a unit whose rotor or stator is not free to turn may differ from the procedure for zeroing a similar unit whose rotor

or stator is free to turn. Refer to Navy Electricity and Electronics Training Series (NEETS) Module 15, for detailed procedures on the adjustment and zeroing of the various types of synchros.

SUMMARY

As with all the work you perform as a Torpedoman, safety plays a key role in maintenance that you are required to perform. We have introduced you to the major concerns with mechanical and electrical safety.

We discussed in general the preventive and corrective maintenance guidelines concerning mechanical and electrical maintenance.

To help you to relate to your mechanical maintenance requirements, we went into some specifics concerning torpedo tubes. In so doing, we discussed surface vessel torpedo tube maintenance and submarine torpedo tube maintenance.

Under electrical maintenance we introduced you to the various elements of a circuit, some of the major causes of failure within a circuit, the six-step troubleshooting procedures, and the different types of circuit checks that you will be expected to perform.

Finally, we discussed the synchro circuit; what it does, some of the problems you might experience with it, and the adjustments you would be expected to perform.

Your responsibilities concerning maintenance cover a wide range. To meet this need, we have exposed you to these different areas and provided the references when needed.

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